USER MANUAL

TM-I

NIEUWKOOP BV Sinds 1957

Tensiometer with electronic output

USER MANUAL TENSIOMETERS

Preface

Congratulations with your **Nieuwkoop** Tensiometer.
The principal of Tensiometers have been used in soil scientific research since 1930.
From that moment the Tensiometer is successfully used in agriculture and horticulture.
Nieuwkoop is manufacturer of Tensiometers in this sector for more than 25 years.
Using Tensiometers will give you a better opinion about soil conditions. This makes it possible to tune irrigation schedules better to the needs of the plants. This will result in a saving of water and nutrients and will give a bigger production.
The Tensiometer is a good help to minimalism the drain. This will result in a better environment.

Thanks to the new line of Tensiometers with electronic output, it is possible to have a continuous control of the soil conditions. This will help you to protect the plants against diseases caused by to much water or less production because of water stress.
From now on guesswork in scheduling irrigation belongs to the past.
Good luck with your Tensiometer.

Summary

Soil particles, water and air are the main elements of every soil around the plant roots. Water can not move freely in the soil but will be hold between the soil particles. How easy water can move in soil depends on the soil type, the capillary attraction and the amount of water.
These values determine how easy a plant can subtract water from the soil (see figure 1 and 2).

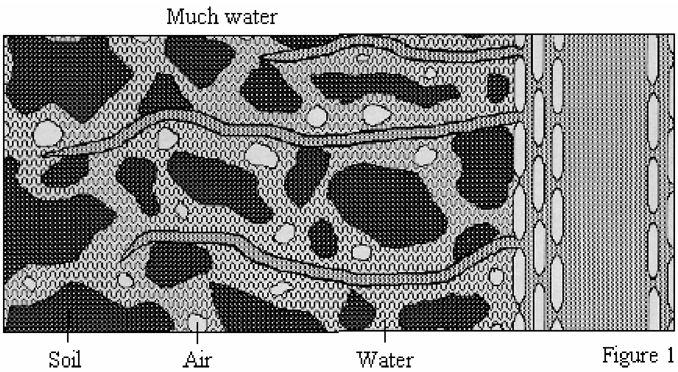


Figure 1

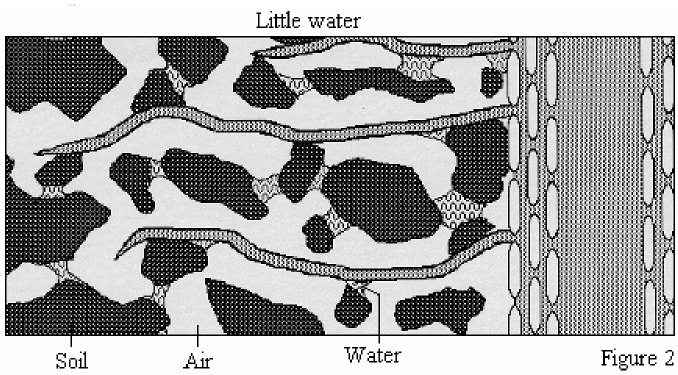


Figure 2

When the soil contains much water and even the big spaces between soil particles are filled with water, the plant roots can subtract the water quite easy from the soil.
When the soil contains less water and only the small spaces between soil particles are filled, the plant has to use more "suction" to subtract water from the soil.

When there is to much water in the soil, soil particles can not hold all the water, so water will drain away (the soil is saturated).
When the water content decrease, at a certain point the plant can not subtract water from the soil anymore (this the withering point).

Measuring principal
Tensiometers are the only instruments that measure directly the suction a plant needs to subtract water from the soil.

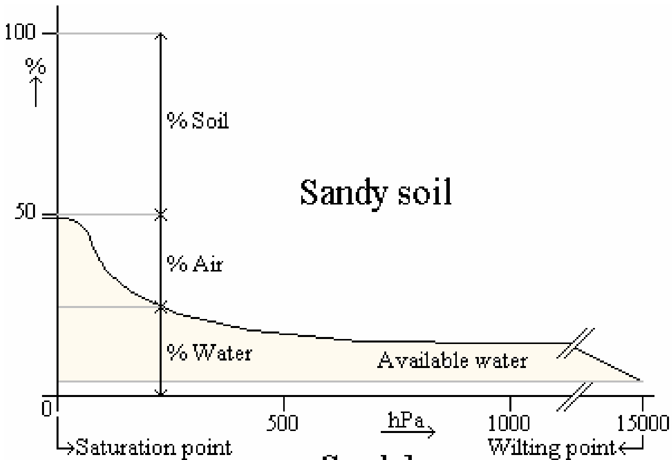
A Tensiometer consists of a hollow tube connected to a ceramic tip at the bottom.
A rubber stopper closes the tube at the upper side. The tube has to be filled with demi-water or distilled water. After this the tube has to be placed into the soil. When the soil gets dry it will subtract water from the tube through the ceramic tip. This will cause a vacuum in the tube. When the vacuum is equal to the suction of the soil, the water flow through the ceramic tip will stop. When the soil gets wet through rain or irrigation, the Tensiometer will subtract water from the soil through the ceramic tip caused by the vacuum into the tube. Because of this the vacuum will decrease until it is equal to the soil suction. When the soil is saturated, water can freely flow in and out the tube, so there will be no vacuum into the tube.

In this way we can see the Tensiometer as a synthetic root of a plant where the vacuum is always in balance with the soil suction.
We can use this as a standard for the suction a plant needs to extract water from the soil.

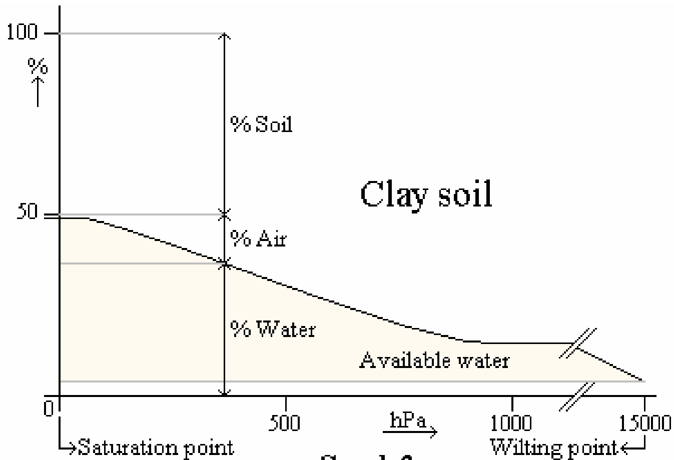
Measuring vacuum
The measuring principle of Tensiometers have been used in soil scientific research since 1930. These Tensiometers used Mercury or water columns to measure the vacuum. Later this was replaced by a Bourdon pressure-gauge. Nowadays vacuum can be measured by electronic sensors. With these sensors it is possible to measure the pressure more accurate. The sensors have an electronic output that can be connected to a controller or computer. The TM-I of Nieuwkoop BV is a Tensiometer of this type.

The international standard for measuring pressure is Pascal (Pa). Other standards for measuring the pressure are: hPa, cm H_2O column or pF. However we will use the international standard and measure in hectopascal (1hPa = 100Pa). The conversion to the other units is: 1hPa=1hPa=1 cm H_2O column. The pF is the logarithmic value of the pressure in hPa.
The pressure in the Tensiotube is measured compared to the barometric pressure. The Tensiometers will be calibrated in this way the pressure will be zero when the tube is placed in water. When water will be extracted to the tube, this will cause a vacuum, so this will be a negative value (for example -100hPa).

In graphic 1 you will find the suction (in hPa) of a certain soil compared to the moisture (in percentage).
This graphic is different for every soil type.



Graph 1



Graph 2

Measuring values
Every soil type has a saturation point and a withering point.
At saturation the suction is 0hPa and at the withering point the suction is about. 15.000hPa.
Between these values a plant can extract water from the soil.
However, in practice the soil suction will stay between 0 and 800hPa and irrigation will take place between these points.
The condition of the soil between these points is mainly as follows:

0hPa
Soil suction of 0hPa means the soil is completely saturated. This can be expected after heavy rainfall or long irrigation. When soil suction will be 0 for a longer period, there will be oxygen starvation to plant roots and development of diseases. A persistent zero reading after irrigation indicates poor drainage conditions.

0-50hPa
When the soil suction is between 0-50hPa there is enough water for the plants.
This suction is normal after rainfall or irrigation. In this measuring range water will drain quickly. When the soil suction will be in this range for a long period (more than two days) this indicates poor drainage conditions. (This damage the plants)

50-200hPa
A soil suction of 50-200hPa means there is enough water and enough air for an optimum growth of plants. Soil suction in this range is called field capacity of the soil. This means soil can not held more water for the plants. All the water what will be irrigated extra will drain after a while.

200-400hPa
The soil suction is good for plant growth in normal soil and soil with fine texture, but in sandy soil the suction can increase quickly. This will cause water stress.

400-600hPa
Soil suction is good for fine texture soils, but in other soils the suction can increase quickly. This will cause water stress.

600-800hPa
Available water for plants is scarce. Even in heavy clay soil the suction can increase quickly. This will cause water stress.

This is a coarse indication of the soil condition for plants.
In practice soil conditions are dependent on soil type and structure.
Beside this some plant types are more sensitive for water stress as others.
Because of this, irrigation scheduling will differ for every user.

Placement and Maintenance

For a representative measurement there are a few things important:

1. Right filling of the Tensiometer with water.
2. The ceramic tip has to make good contact with the soil.
3. The Tensiometer have to be placed on a representative place.
4. The pores of the ceramic tip may not get choked-up.

1. Before placement the Tensiometer has to be filled with water.
Remove the rubber stopper from the Tensiometer. Fill the tube with **distilled or boiled water**. Avoid air bubbles in the tube. Push the rubber stopper **carefully** back into the tube (the tube may not have a leak).
Place the ceramic tip of the tube during a few hours into water.
When the Tensiometer is placed into the soil, it will leak water very slowly. How quick this will happen depends on the soil suction. (In practice the tube will start leaking water above ±600hPa) This will give an air column at the top of the tube. This air gives a delay in reaction time. Therefor we advise to refill the tube when the air column gets bigger than 1 cm. This can be done by removing the rubber stopper, refilling the tube with distilled water and pushing the stopper **carefully** back into the tube. Because of this, the Tensiometer will lose its vacuum, so it will take a while before you can read out values again.

2. For a representative measurement the ceramic tip has to make good contact with the surrounding soil.
In soft soil the tube can be pushed directly into the soil. In hard soil firstly we have to drill a hole with the same diameter as the Tensiometer.
The ceramic tip of the Tensiometer is breakable **so be careful with placing the tube.**
Press the soil around the tube firmly and make the soil wet. This will give the soil it's old structure back and irrigation water flowing along the tube will be avoided.
Because the soil is wet, it will take some time before you can read out the Tensiometer (±1 day).

3. The Tensiometer has to be placed on a representative place.
Place the Tensiometer between the plants. How deep the Tensiotube has to be inserted into the soil depends on which purpose the Tensiotube is used for. When the Tensiotube is used for scheduling irrigation, it has to be placed in the active root zone with the ceramic tip between the roots. This is the place where plants extract water from the soil.. For deeply rooted plants we advise to use two Tensiometers; one at ¼ of the root zone and one at ¾ of the root zone. Because of this we get a better view of the soil suction over the complete depth of the root zone. Place these two Tensiometers close together to avoid different readings because of difference in soil structure etc. When the Tensiotube is used for controlling the drain, place the tube with the ceramic tip under the active root zone, right between the root zone and the groundwater (until max. 80cm deep).
Place the Tensiometer on a place that is representative for the whole parcel. When some places on a parcel differs in moisture because of soil structure, soil type or difference in height. Place in both areas a Tensiometer to get a complete view in soil suction over the whole parcel for a good scheduling of irrigation. Place Tensiometer always in the shadow. (This to avoid temperature deviation)

4. The pores of the ceramic tip could choke-up after a while.
To prevent this, clean the ceramic tip every half year with a household cleaner.

N.B. The soil suction is measured through the water into the tube. Because of this the Tensiometer will not work when it is freezing. So do not use the Tensiometer below temperatures of 1°C.

Tensiostations
To have a good view over the soil suction we advise to use more Tensiometers at different depths close together. We call this a Tensiostation.

In figure 3 are three different Tensiotubes placed. Tensiometer "A" is placed with the ceramic cup in the middle of the root zone of the plants (here 20cm).
Tensiometer "B" is placed with the ceramic cup just under the root zone (here 35cm).
The ceramic tip of Tensiometer "C" is placed in the middle between Tensiometer "B" and the groundwater level (here 60cm).
The depths mentioned in the drawing are examples. These will differ for everyone. The depth of the root zone depends on plant type (use for deeply rooted plants two Tensiometers as mentioned in point 3 at page 4). The depth of Tensiometer "C" depends on the groundwater level. Do not placed Tensiometer "C" deeper as 80cm.

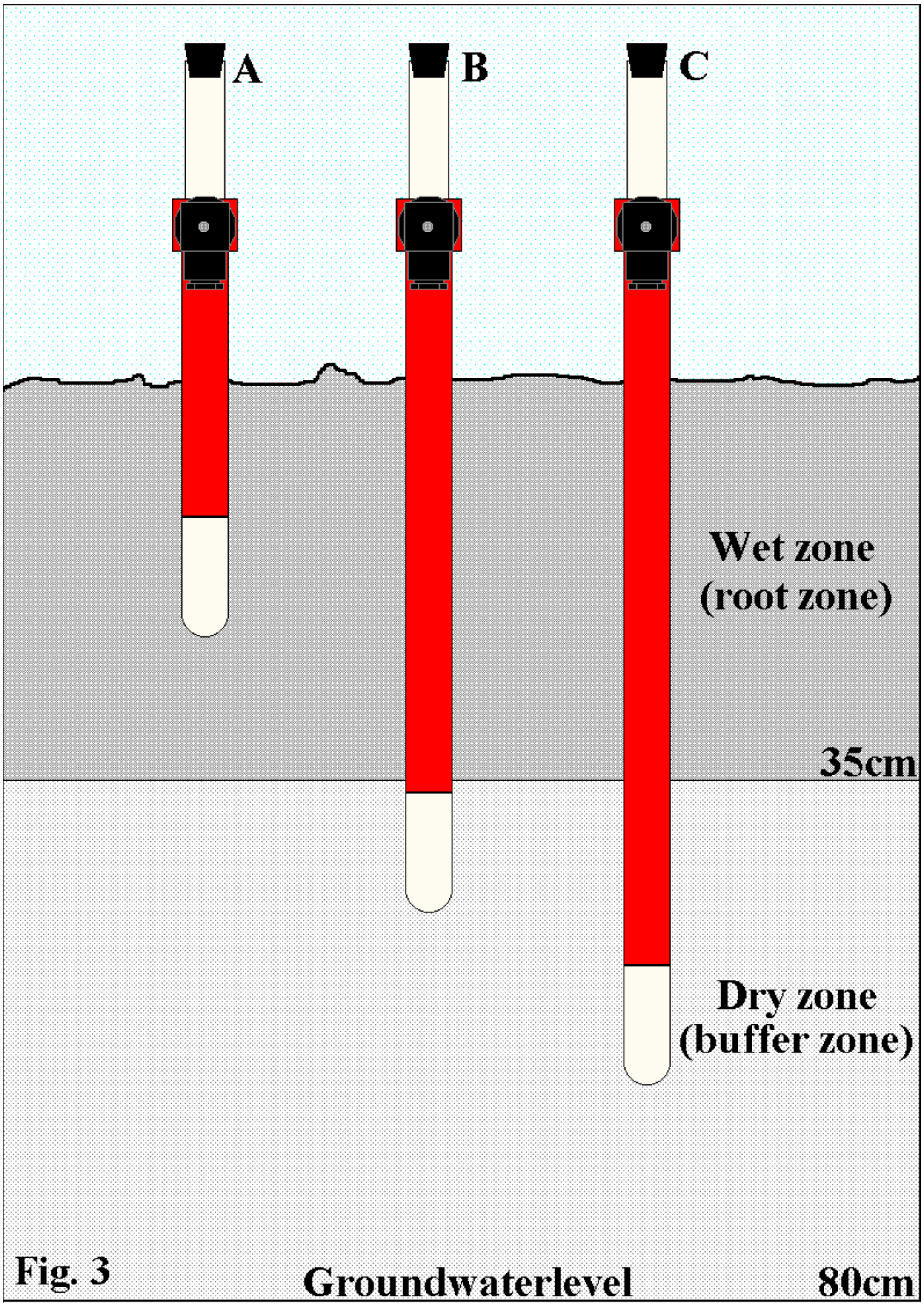
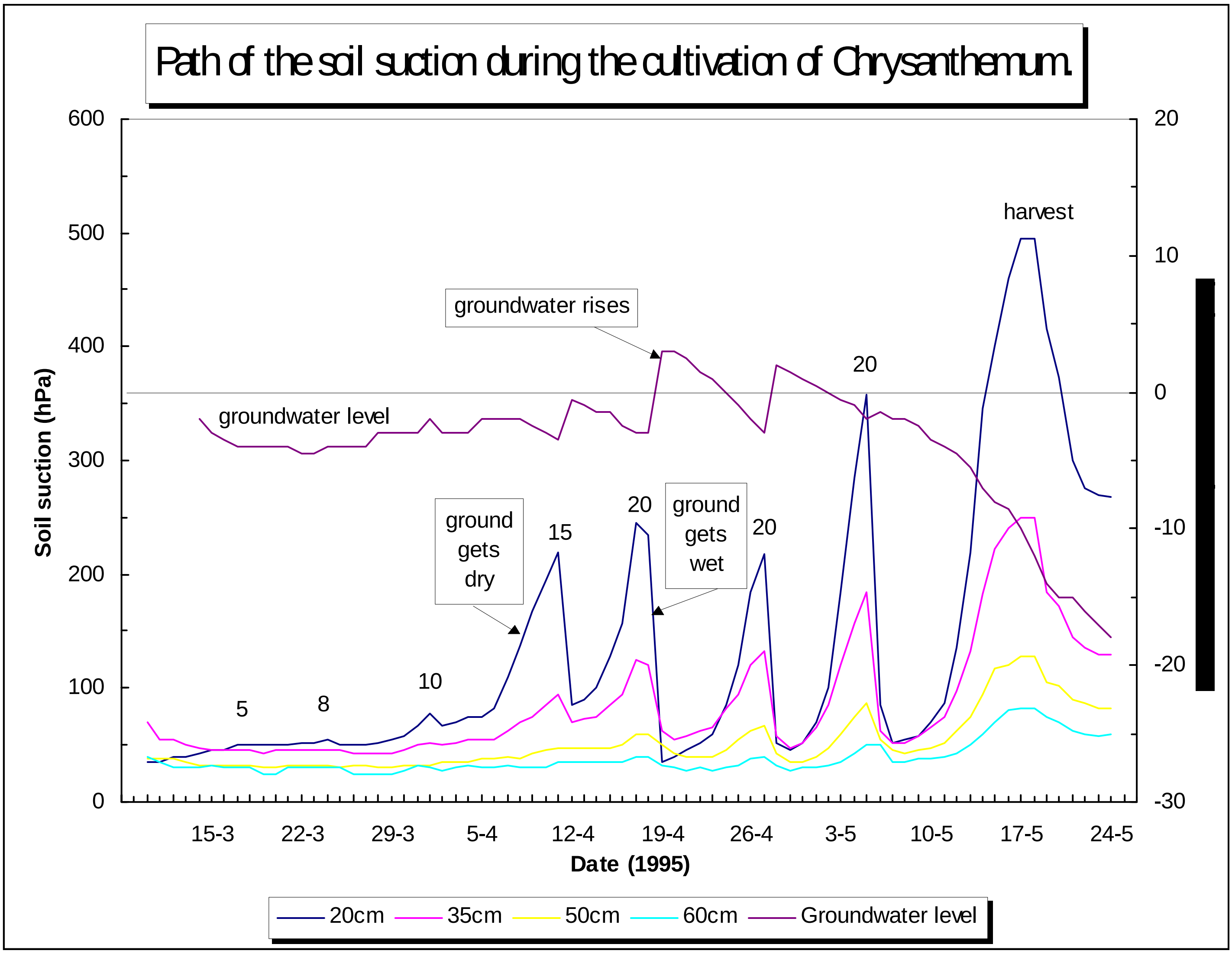


Fig. 3

In this way we will get a good view over the soil suction until 60cm deep into the soil.

this makes it possible to create a wet zone of soil where roots can grow, with under this zone a dry zone until the groundwater. In this way drain will be minimised.
Tensiometer "A" is used to schedule irrigation. With Tensiometer "B" the water flow from the wet to the dry zone will be measured. Tensiometer "C" is to control if the dry zone stays dry enough. This to avoid drain to the groundwater (the Tensiometer value may not change after irrigation).
In this way we can fix the right time and duration of irrigation. There has to be irrigated in this way the wet zone stays at field capacity (then there will be enough water for the plants but no drain). The irrigation time may not be to long.
It is very important to use an irrigation system which irrigates uniform, and the irrigation water has to be very clean (because of salt increasing).

We advise to connect the Tensiostations to a computer in order to make graphics of the soil suction over a few weeks or even a complete cultivation period. This will give an overview of the soil suction over a longer period. With this information we can schedule irrigation in a way the soil suction gets as equal as possible. So it is not only important to control the actual value of the soil suction, but also the variations over a longer period. The graphic below is an example of the variations in soil suction in a chrysanthemum cultivation (source: Denarkas BV).



The numbers in the graphic give the irrigation in l/m^2.

Connection and calibration of the TM-I

For electrical connection of the Tensiometer a 2-wire cable is required.
Remove and open the connector of the Tensiotube. Connect to the +Ub input (connection 1) a power supply between 9 and 30Vdc. The -Ub/out (connection 2) is the 4-20mA output of the Tensiometer. 4mA is equal to 0hPa and 20mA is equal to 600hPa. De enclosure of the transmitter is IP65 watertight. **When the Tensiometer is located outside or under an irrigation unit, place the plastic protection cap over the Tensiotube.** This to protect the electronics.

IMPORTANT. The Tensiometers are calibrated in the factory conform the specifications. However the water column of the Tensiotube is not calculated in this calibration. So at the zero-point the tensiometer will indicate a value (in hPa) equal to the length of the tube in cm (for example a tensiotube of 30cm will indicate at the 0-point ± 30hPa). This can be compensated as follows:
Place the tube until half of the porcelain under water. Wait until the readout has stabalised and calibrate on 0hPa with the device where the Tensiometer is connected to.
We advise to return the Tensiometer once a year to Nieuwkoop BV or your own supplier for calibration.

Technical specifications:

Type	:	TM-I
Brand	:	Nieuwkoop BV - Aalsmeer - Holland
Range	:	0-600hPa underpressure
Max. pressure	:	2 times the range
Output	:	4-20mA (4mA=0hPa, 20mA= -600hPa)
Non linearity	:	Typ. ±0,25%, max. 0,5% of the scale
Hysterese	:	Typ. ±0,25%, max. 0,5% of the scale
Power supply	:	9-30Vdc
Temp. sensitivity 0-point	:	Typ. ±0,02%, max. ±0,04%/°C of the scale 0…+85°C
Temp. sensitivity Span	:	Max. ±0,005%/°C of the scale 0…+85°C
Working temperature	:	1…85°C
Accuracy 0-point/Span	:	1% (exclusive water column), better accuracy possible by means of individual calibration
Membrane	:	Ceramic
Housing	:	Stainless steel 1.4305/IP65
Connector	:	DIN 43650A
Tensiotube lengths	:	30, 60 and 90 cm, other lengths on request
Tube ø	:	20mm
Weight 30, 60 and 90cm	:	resp. ca. 300, 360 and 420 gram.
Accessories	:	Syringe 60cc and an user manual
Warranty	:	1 year